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Research Article

Markov chain modeling of daily rainfall in Lay Gaint Woreda, South Gonder Zone, Ethiopia

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Abstract: An understanding and knowledge of seasonal rainfall distribution, e.g. length of the growing season and rainfall extremes, is very important in agro-based economies like Ethiopia, where 95% of the farmers depend on rainfed agricultural production. The distribution pattern of rainfall rather than the total amount of rainfall within the entire period of time is more important for studying the pattern of rainfall occurrence. Zero, first and second order Markov chain was used to describe the characteristics of rainfall occurrences in this woreda. The states considered were; dry (d) and rainy (r).The overall chance of rain and the fitted curve tells us that the chance of getting rain in the main rainy season is quadruple as compared to the small rainy season. The first order Markov chain model indicates that the probability of getting rain in the small rainy season is significantly dependent on whether the earlier date was dry or wet while the second order Marko chain indicates that during the main rainy season the dependence of the probability of rain on the previous two dates' conditions is less as compared with the small rainy season. Rainfall amounts are very variable and are usually modeled by a gamma distribution.Therefore, the pattern of rainfall is somewhat unimodial having only one extreme value in August. Onset, cessation and length of growing season of rainfall for the main rainy season show medium variation compared to the small rainy season.

Keywords: *cessation, gamma distribution, length of growing season, Markov chain, onset*

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Introduction

An understanding and knowledge of seasonal rainfall distribution, e.g. length of the growing season and rainfall extremes, is very important in agro-based economies like Ethiopia, where 95% of the farmers depend on rain fed agricultural production (Simelton et al., 2013). Many authors have used Markov chains to model the daily occurrence of precipitation. Gabriel and Neumann (1962) analyzed the occurrence of rain at Tel Aviv, Israel, by fitting a two sate, first-order Markov chain. The two states corresponded to 'rain' and 'no rain'. They used Markov chain probability model to study the data of daily rainfall occurrence at Tel Aviv (Senthilvelan et al., 2012). Markov chain models have played a major role in modeling wet day sequences. Two of the most attractive features Markov chain models are the ease with which seasonality is accommodated and availability of effective statistical inference procedures for parameter estimation and model selection (Stern and Coe, 1984).The distribution pattern of rainfall rather than the total amount of rainfall within the entire period of time is more important for studying the pattern of rainfall occurrence (Garg and Singh, 2010). Rainfall is the principal phenomenon driving many hydrological extremes such as foods, droughts, landslides, debris and mudflows;

its analysis and modeling are typical problems in applied hydrometeorology (Barkotulla, 2010). Rainfall exhibits a strong variability in time and space across the globe. Hence, its stochastic modeling is necessary for the prevention of natural disaster. In this regard, dry and wet spell analysis at decadal time unit (tem day basis) more or less satisfies the required supportive information for decision making in rainfall water resource management and planning in agricultural sectors (Baron, 2004; Reddy et al., 2008). Garg and Singh (2010) studied the pattern of rainfall at Pantnagar for daily rainfall data of 42 years (1961-2002) using a three-state Markov chain model. They divided each year into three periods and calculated transition probability matrices for seasons of dry, wet and rainy for each of the period. Therefore, to overcome this kind of problem more precise and appropriate research methods and models should be employed. As a result, modeling dry spell length and rainfall amount would solve data restrictions which enable to make agricultural planning.

As cited by Muluneh (2015), climate variability and change are affecting the whole world (IPCC, 2007). The impacts are significantly negative on rain fed agriculture (Travis et al., 2010) on which the economies of most developing countries depend (Lamboll et al., 2011) with less adaptive capacity (UN-OHRLLS, 2009). Africa in general and Sub Saharan Africa (SSA) in particular is the most vulnerable region in the world to climate variability and climate change (Michael, 2006). In recent decades, the raising temperature is associated with increased spatial and temporal variability in amount and distribution of rainfall that exceeded the long term spatial and seasonal variability (Ayalew et al., 2012; Tayeet al., 2013). As cited by Getachew (2017), Ethiopia is not an exception to the adverse impacts of climate change as its economy is highly dependent upon climate sensitive rain-fed agriculture. The country is among the most vulnerable nations to climate and ecological change, given that only a small proportion of its cultivated land is irrigated and food production is dependent mainly on traditional rainfed agriculture (NMA, 2007). Despite such adverse events, the average total annual rainfall over the country remained fairly stable over the last 50 years (NMA, 2007). Nevertheless, disaggregated studies revealed different (positive, negative or no) trends among stations in the north western, northern and central parts of the country (Ayalew et al., 2012; Hadgu et al., 2013; Kassie et al., 2014). According to Bewket (2009), crop production is significantly associated with rainfall distribution in its onset, cessation and amount during rainy season. Hence changes in timing of onset disrupt farmers' practices of land preparation and sowing while its distribution and cessation greatly affects crop growth, yield formation and harvesting.

According to Hadgu et al. (2013), analysis of trends in rainfall events such as onset, cessation, dry spell, wet spell and number of rainy days is more important than annual and seasonal totals in the dry lands where seasonal rainfall variability is high. Previous studies in many parts of Ethiopia emphasized on analysis of trends in annual and seasonal rainfall totals (Mekasha et al., 2014) disregarding intra-seasonal rainfall variability such as timing of season start date and season end date , number of rainy and dry days, dry spells at different lengths and other vital aspects of rainfall variability for agricultural planning. To this effect, this study is aimed at to modeling daily rainfall occurrence and amount to fill the gap which is still not addressed by the previous studies particularly in the study area. The length of the growing season in any given region refers to the number of days when plant growth takes place. The growing season often determines which crops can be grown in an area, as some crops require long growing seasons, while others mature rapidly. Growing season length is limited by many different factors. Depending on the region and the climate, the growing season is influenced by air temperatures, frost days, rainfall, or daylight hours.

Changes in the length of the growing season can have both positive and negative effects on the yield and prices of particular crops. Overall, warming is expected to have negative effects on yields of major crops, but crops in some individual locations may benefit (IPPC, 2014). A longer growing season could allow farmers to diversify crops or have multiple harvests from the same plot. However, it could also limit the types of crops grown, encourage invasive species or weed growth, or increase demand for irrigation. A longer growing season could also disrupt the function and structure of a region's ecosystems and could, for example, alter the range and types of animal species in the area. The present work is motivated as a way of gaining further insight into the pattern of rainfall distribution in the tropics especially the Sub-Sahara African region. The study describes the pattern of rainfall distribution in Lay Gaint woreda in south Gonder zone. A Markov chain approach was employed to determine the probability of transitions between the two major daily weather conditions (dry and rainy) in Lay Gaint woreda. Results from this work would provide a useful guide to policy makers, agriculturists, government and the likes in many areas that might require adequate knowledge of pattern of rainfalls and its distributions in Ethiopia.

Materials and Methods

Description of the study area

The study was conducted in Lay Gaint woreda of south Gonder zone, Ethiopia. Geographically the woreda is located between 11° 02' N latitude and 38° 43'E longitudes (Figure 1). The mean annual rainfall in the woreda is about 1,052 mm with a mean annual temperature of about 14^0 C.Data on daily rainfall for thirty four years from January1, 1979 to December 31, 2013 were collected from Bahir Dar meteorological station. The daily rainfalls for the two seasons of spring (Belg) and summer (Kiremet) were studied and recorded. There were no missing observations in the entire daily rainfall data recorded.

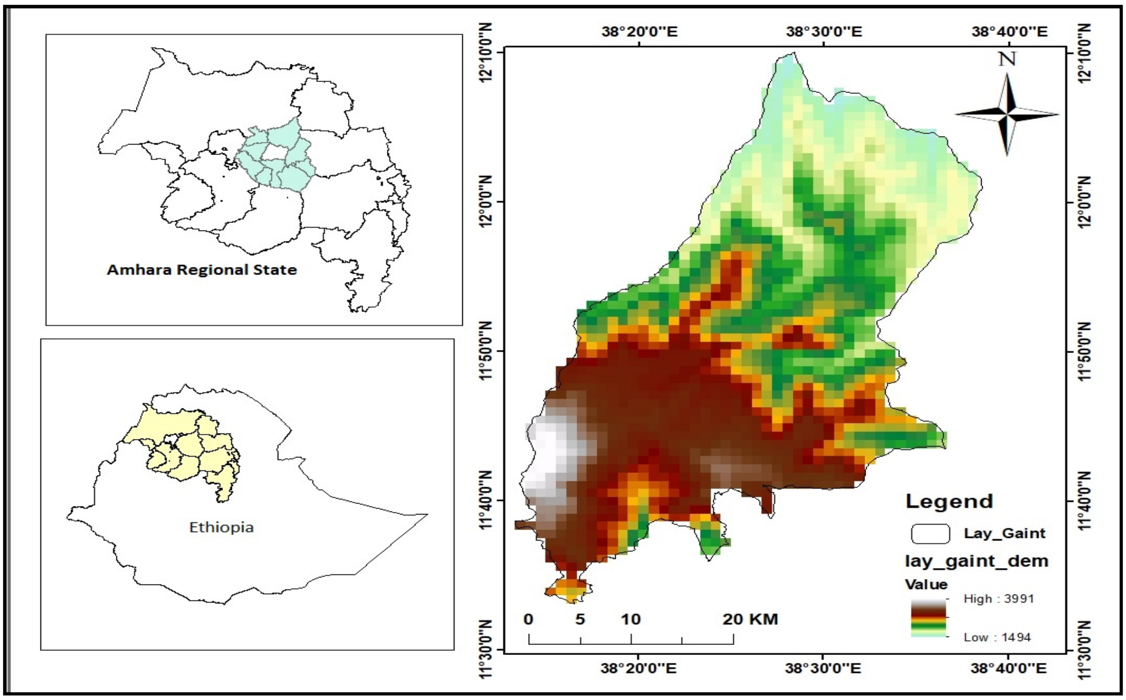

Figure 1. Map of the study area

A two-state Markov chain was used to describe the characteristics of rainfall occurrences in this woreda. The states considered were; dry (d) and rainy (r). The probability of the process being in a particular state was calculated based on the Markov chain assumption that attaining a state depends on the immediate preceding state only. The conditions of rainfall occurrence for the two states were defined as follows: a day was considered dry if rainfall occurrence on that day was not more than 0.85mm and rainy if rainfall occurrence greater than 0.86mm. Markov chain, transition probability matrices, probabilities of dry and rainy days in the long run (equilibrium), expected length of season's spell and Weather Cycle (WC) shall be determined in the analysis of daily rainfall data for the periods of spring (February 1 – April 30) and summer (June 22 – September 21)) for Lay Gaint woreda, south Gonder zone, Ethiopia. A Markov chain is a special category of stochastic process where the state space and index are discrete in nature. It is a discrete-time process for which the future behavior of the process, given the past and the present, only depends on the present and not on the past (Udom, 2010). Another property of a Markov chain is that the transition probability matrices are the result of the processes that are stationary in time or space; the transition probability does not change with time or space (Udom, 2010). Data collected on rainfall occurrences over a sequence of days can be modeled as a two-state Markov chain with state space S = d, r. The current day's rainfall was expected to depend only on that of the preceding day; thus, the observed frequency of days of being in a particular atmospheric state j having just left atmospheric state i, i, j = (d; r) are presented. The definitions of the notations used are provided below;

Ndd : Number of dry days preceded by dry days

Ndr : Number of rainy days preceded by dry days

Nrr : Number of rainy days preceded by rainy days, and so on.

Rain occurrence

Occurrence of rainfall is described by a two state Markov chain (day is wet or dry) of first order, that is the probability of rain on a given day depends on whether or not rain occurred on the previous day. The approach has been used successfully and studied extensively to generate rainfall (Larsen and Pense1982; Roldan and Woolhiser, 1982; Richardson 1985).

Let $X_{0,}$ X_1, X_2…Xn, be random variables distributed identically and taking only two values, namely 0 and 1, with probability one, i.e,

0 if the n^{th} day is dry

Xn= 1 if the n^{th} day is wet

Firstly, it may be assumed that,

P(Xn+1=Xn+1|Xn=Xn,

Xn-1=Xn-1,…, X0=X0)=P(Xn+1=Xn+1|Xn=Xn)

Where X0, X1…Xn+1$\in$\{ 0, 1 \}.

In other words, it is assumed that probability of wetness of any day depends only on the previous day was wet or dry. Given the event on previous day, the probability of wetness is assumed independent of further preceding days. So, the stochastic process $\{X_n\}$n=0,1,2,… is a markov chain (Medhi, 1981). Consider the transition matrix as

$$\begin{bmatrix} P_{10} P_{01} \\ P_{10} P_{11} \end{bmatrix}$$

where, *P*ij = P(X1 = j|X0 = i) i, j = 0, 1 that is *P*01 = the conditional probability of a wet day following a dry day, *P*11 = the conditional probability of a wet day following a wet day. The complementary probabilities for dry day occurrences are given by *P*00 = 1- *P*01 and *P*10 = 1- *P*11 such that, *P*00+*P*01 = 1 and *P*10+*P*11 = 1.

The transition probabilities are considered on a monthly base and then the model requires 24 parameters for the rain event generation (12 for *P*01 and 12 for *P*11). These probabilities are calculated on all the available recordings in the data set as: *P*01 = N01/N0 and *P*11 = N11/N1 where, N01 is the number of wet days after a dry day in the month; N0 is the total number of dry days in the data set, for the month; N11 is the number of wet days after a wet day in the month; N1 is the total number of wet days in the data set, for the month.

Fitting of Gamma Distribution

The gamma distribution is frequently and successfully used for modeling the non-zero amounts of rain (Stern and Coe, 1984; Siddiqi, 1992; Hussain, 2004; Sharda and Das, 2005). The p.d.f. of the gammadistribution is given by

f (y) = $(k/\mu)^k$ y^{k-1} e^{-ky}/μ/ Γ (k) Γ (k), k > 0, 0≤y ≤∞. = 0, otherwise.

Where the μ mean rain per rainy day is, Γ is the gamma function and k is the shape parameter. The coefficient of variation is given by 1/√k, when k=1, the gamma distribution is the exponential distribution

Results and Discussion

The proportion of rainy days estimates the probability of rain, on any given date in the study area. Figure 2 shows the overall chances of rain and the zero order Markov chain fitted curve. Zero order Markov chain consider just the two categories of dry and rain conditions.The fitting of a single curve corresponds to a zero-order Markov chain. A zero-order chain is one that has no memory. The fact that yesterday was dry does not affect the chance of rain today.Hence, result shows the overall chance of rain in the main rainy season (June to September) is significantly higher compared with the small rainy season (Feburary to April). Therefore, the probability of rain during the small rainy season is slightly higher than 20% whereas the chance of rain during the main rainy season especially during July and August is more than 85% of the rainy season of the year. Generally, the overall chance of rain and the fitted curve tells us that the chance of getting rain in the main rainy season is quadruple as compared to the small rainy season.

According to Stern et al. (1982), the probability of getting rain on a particular date is dependent on whether some of the previous dates are wet or dry in some places of the world. Therefore, in order to reach an accurate decision for both first and second order Markov chain analysis was carried out. The first order Markov chain analysis deals with computation of chances of rain depending on whether a previous date was dry or wet.If the chain is first-order, then the fact that yesterday was dry may affect (i.e. change the probability) that today is rainy. However, with a first-order chain, the extra information that the day-before-yesterday was also dry does not further change the probability of rain today. Figures 3 and 4 show the conditional probability of receiving rain at Nefas Mewcha station. Figure 4 indicates that the probability of getting rain on a certain date in the small rainy season substantially increase, if it is followed by a wet day (p_rr). On the other hand, the probability of getting rain in the small rainy season will decrease significantly, if it follows a dry date (p_rd). Thus, the chance of getting rain on a spring season is greater than 50% while during summer season the chance of receiving rain is higher than 80% if it is followed by a wet date. On the other extereme the chance of getting rain on a spring season is smaller than 20% if it is followed by a dry date. This condition recommends that the probability of getting rain in the small rainy season is significantly dependent on whether the earlier date was dry or wet.

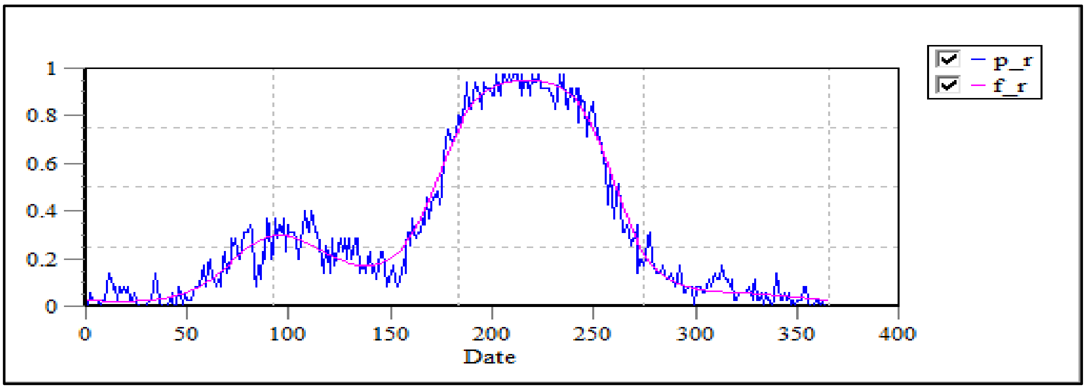

Figure 2. Observed and fitted (0-order Markov Chain) proportion of rainy days at Nefas Mewcha station based on 1979-2013 rainfall data

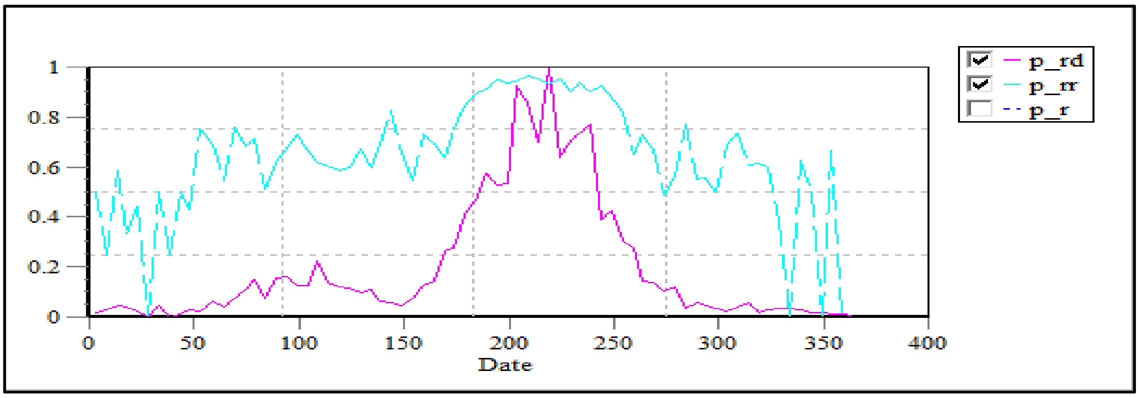

Figure 3. Probabilities of rain at Nefas Mewcha station on whether a previous date is dry or wet

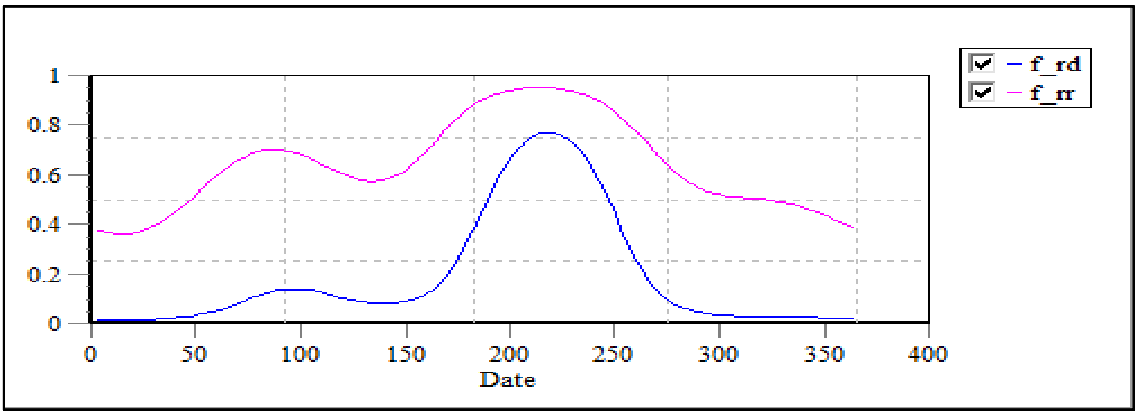

Figure 4. First order Markov Chain fitted curves for probabilities of rain at Nefas Mewcha

In order to check whether the probability of getting of rain on a particular date is reliant on the conditions of the previous two days, a second order Markov chain analysis need to be done. Hence, with a second-order chain the memory extends two days. Therefore, Figures 5 and 6 portray the second order Markov chain analysis.

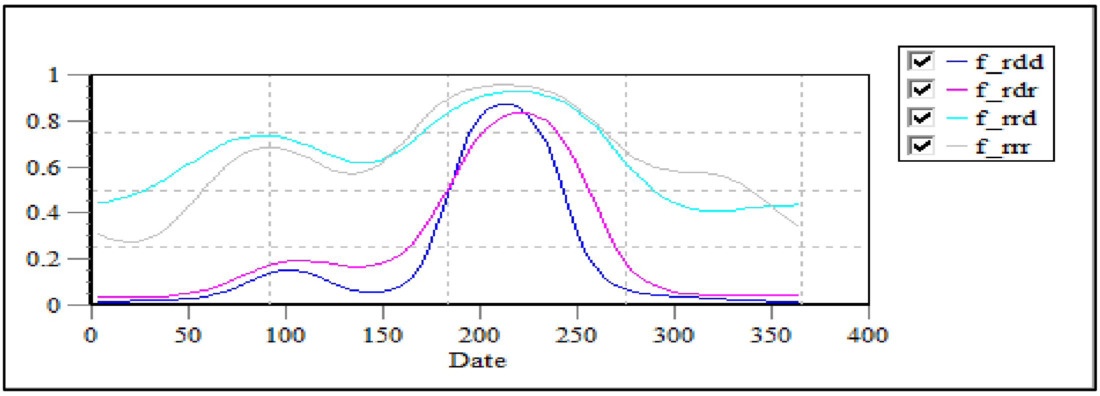

Figure 5. Second order Markov Chain curves for probabilities of rain at Nefas Mewcha

By comparing Figures 5 and 4 it is possible to conclude that four curves of second order Markov chain are sufficient to describe the probability of rain at Nefas Mewcha station. This is because the curves are relatively closer to each other in the second order (Figure 5), even in the small rainy season, than in the first order (Figure 4). However, the f_rdd curve of Figure 5 shows very low probabilities in the small rainy season. The maximum probability in the small rainy season related to this curve (i.e. f_rdd) is about 10%. Hence, the probability of getting rain in the small rainy season (i.e. spring season) is not greater than 10% if the previous two days are dry. Whereas the maximum probabilities of getting rain on summer season vary in between about 50% to 70% if it is followed by two consecutive wet days (f_rrr) and alternative dry and wet days (f_rrd). Therefore, Figure 5 indicates the low likelihood in the small rainy season, related to two previous dry days, tells us that dry spells are likely to persistent in the small rainy season as compared to the main rainy season. The relatively higher probabilities associated with two previous wet days also tells us that the probability of getting rain in the small rainy season is strongly dependent on the two previous days' conditions. On the other hand, in the main rainy season, the probability of rain on the previous two date conditions is less dependable as compared with the small rainy season. Hence, the chance of getting rain in the main rainy season (summer season) is not dependent on the previous two conditions. Therefore, either the previous two consecutive days were wet or dry does not have significant influence on the occurrence of rain in any given date.

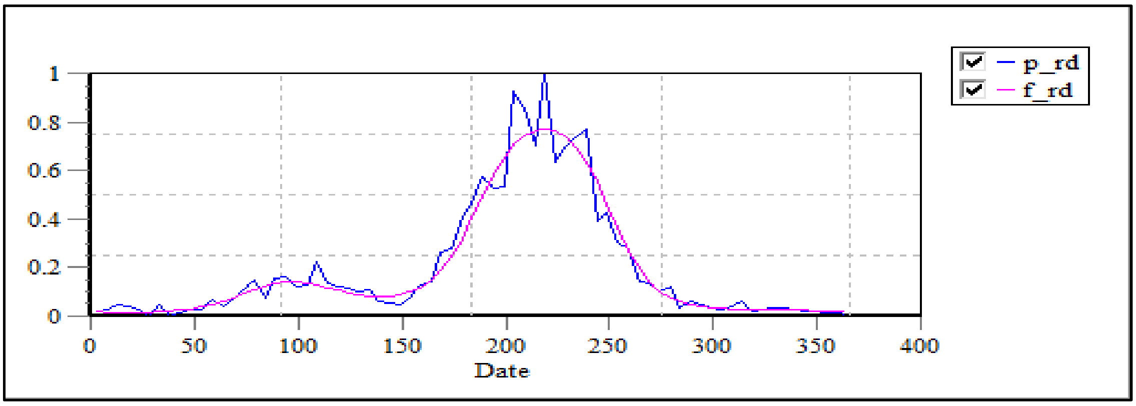

Figure 6. The chance of rain following a single dry day

Figure 6 shows the chance of rain after a dry spell of a single dry day. The curve indicates the chance of a dry spell of a single dry is lower in the main rainy season compared to the small rainy season. Hence, the chance of rain spell continuing raise to about 7/10 in August (i.e. 70%).

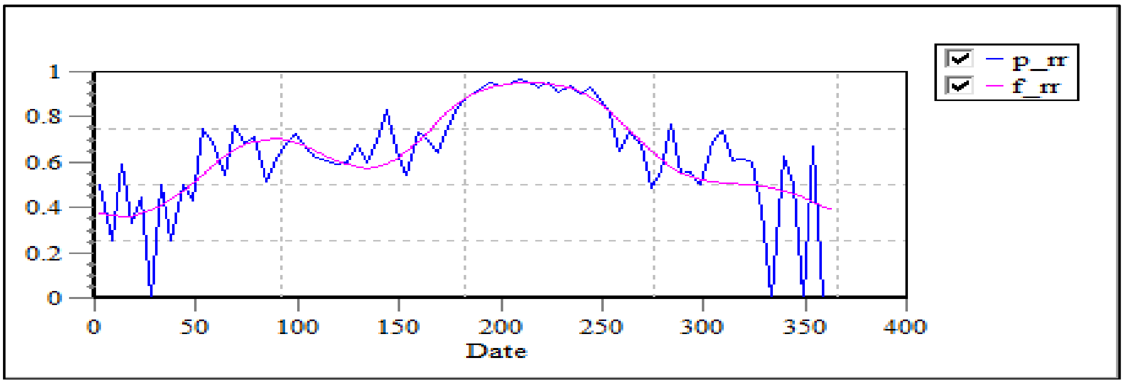

Figure 7. Chance of rain following a rainy day

The chance of rain depends on whether the previous day had rain or was dry. The curve in Figure 7 shows the chance of rain when the previous day also had rain. This is therefore the chance that a rainy spell continues for a further day. In August 200 DOY(Days Of Year) for the middle of the rainy season is over 0.9, i.e. about 9/10 of rainy days continued and had rain on the next day.

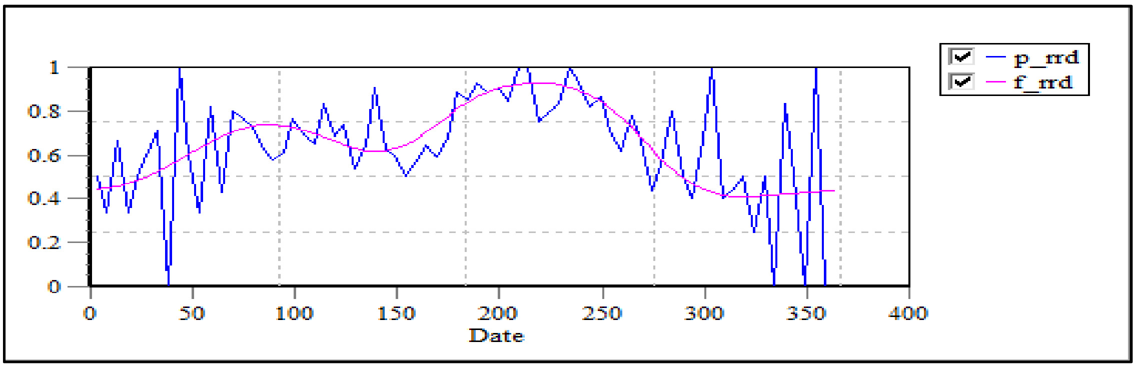

Figure 8. The chance of rain following a dry spell of two or more days

The above curve in Figure 8 is the chance of rain if yesterday was dry, but the day before that was rainy, i.e. the chance of rain after a single dry day. The difference between Figure 7 and the Figure 6 shows the chance of rain 'returning' is greater after just a single dry day, than if a dry spell has been remain for two days or more. The model that has been fitted to the chance of rain might therefore be thought of as having a 'memory' of two days, if the previous day is dry. Therefore, the chance of getting rain following two consecutive dry days is in between 40% to 70% in the spring season while the probability of getting rain following two consecutive dry days is higher than 80% during summer season.

When there is rain, the rainfall amounts on a rainy day have a mean that is estimated by the curve shown in Figure 9. Therefore, The rainfall amounts on rainy days are also modelled using Markov chain. The mean rain per rain day is 10 mm is the peak of the rainy season. Rainfall amounts are very variable and are usually modeled by a gamma distribution. The observed and fitted mean rain per rainy day is given in the model (Figure 9). The model in this figure appears to be almost fitting from January to December. The minimum mean amount of rain is 2.5 mm in January, February, November and December whereas, its maximum value is 10.0 mm occurs at the beginning of August. It is very important to note that for drier months, the number of years in which day that had rain is relatively less. It means that few observations are available to calculate the observed mean per rainy day and this has some effect in estimating the shape of the curve for such months. On the other hand, the amount of rain at the beginning and end of the year is almost the same, i.e., 2.5mm. The amount of rain is high during the main rainy season compared to small rainy season. Therefore, the pattern of rainfall is somewhat unimodial having only one extreme value in August.

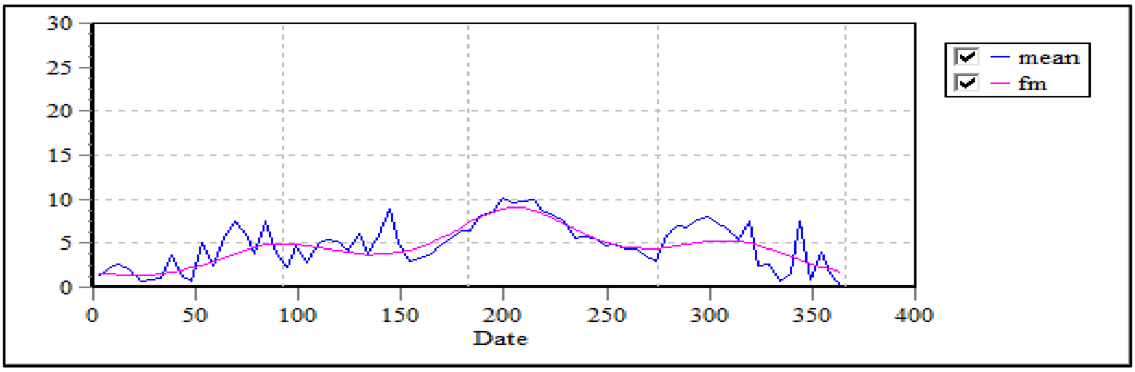

Figure 9. The mean rain per rainy day (mm)

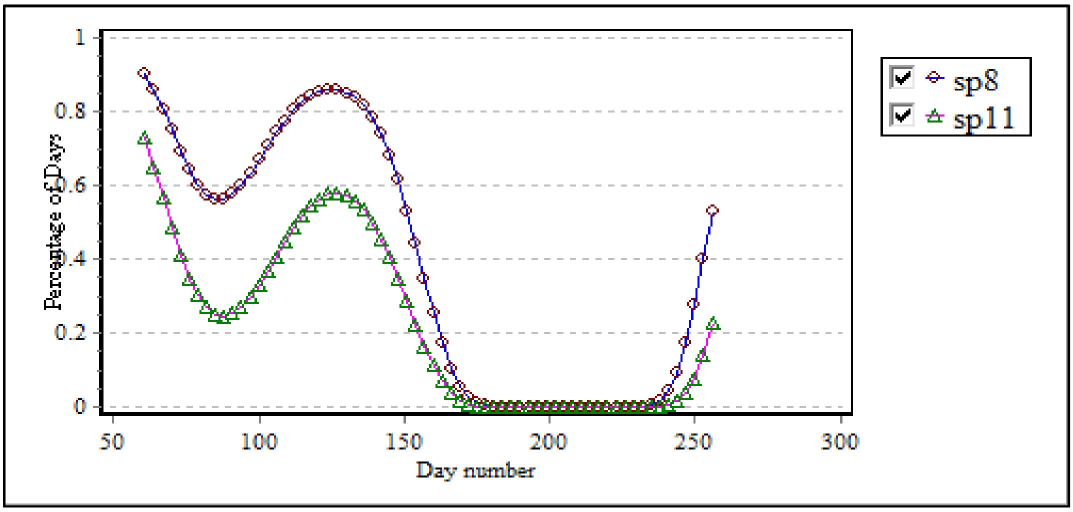

Figure 10. Dry spell following planting

In the study area, the probability of dry spells length of 8 days was found to be greater than 80% during 125 days of the year (1st decade of May) then it decline to below 20% by 160 days of the year(2nd decade of June (Figure 10). Starting from 250 days of the year, the probability the area to face dry spell length of 8 and 11 days increased up to 65% and 30% 3rd decade of September. Hence, if the farmer planted crops which could not withstand 8 days of dry spell, the chance of crop failure would be about 65% to 30%. On the other hand, during the main rainy season of the study area JJAS (i.e. June, July, August and September), the probability of the occurrence of dry spell length of 8 and 11 days had been reached 0% beginning from the 3rd decade of June up to the 2nd decade of September. Therefore, this season is very essential for planting of crops. To this effect, during the main rainy season the study area was not influenced by very influential dry spell length which reduced the growth stage of the crops. The models fitted in Figures 6, 7, 8 and Figure 9 has used all the daily data in the climatic record for Nefas Mewcha. If this model is appropriate it can now be used to calculate any of the same ‘events’, such as the start of the rains, and risk of dry spells, that have been modeled in the previous sections. For simple events, such as the risk of a long dry spell, results can be calculated probabilistically as described in Stern and Coe (1984). Otherwise simulation (of many years) is used, as for example by Marksim (Jones and Thornton, 2000). Information on the length of dry spell is very important to farmers to decide on crop types to be cultivated and on planning sowing dates as a function of the onset dates. Besides, information on dry-spell lengths could be used in decision making with respect to selecting dry spell resistance crop and field operations within the farming system. The dry spell effects on crop growth are related to water requirement of the crop and soil water holding capacity. Thus, whether soil has high or low water holding capacity information is extremely useful for planning and designing applications for crop production. The peak rainfall period during the growing season occurs between July and August in the study area. The risk of 8 and 11 days of being dry spell decreases from April to June and again there is a rapid increase in chances for experiencing dry spells after receiving rain in the 3rd decade of September. For spring season, the first occasions with more than 20mm in 1 or 2 days after 1st March was considered whereas the first occasions of summer season with more than 20mm in 1 or 2 days after 15th of June was considered for the analysis.

Table 1. Start Of Season (SOS); End Of Season (EOS) and Length of Growing Season (LGS) of both summer and spring season at Nefas Mewcha station

Indices	**Nefas Mewcha Station**		
	Summer(Kiremet)		Spring (Belg)
SOS	Latest (DOY)	214(01 August)	213 (31 July)
	Mean (DOY)	188 (06 July)	140 (19 May)
	Median (DOY)	188(06 July)	137 (16 May)
	Earliest (DOY)	167(15 June)	63 (3 March)
	CV (%)	7	37
	SD (days)	12.61	52.3
	75 percentiles	196(14 July)	193 (11 July)
	25 percentiles	178 (26 June)	86 (23 March)
EOS	Latest (DOY)	312 (07 November)	295 (21 October)
	Mean (DOY)	272(28 September)	129 (08 May)
	Median (DOY)	266 (22 September)	122 (01 May)
	Earliest (DOY)	259 (15 September)	122(01 May)
	CV (%)	5	23
	SD (days)	14	29.69
	75 percentiles	282 (08 October)	122 (01 May)
	25 percentiles	259(15 September)	122 (01 May)
LGS	Latest (Days)	145	225
	Mean (Days)	83	-10.97
	Median (Days)	82	-15
	Earliest (Days)	46	-91
	CV (%)	27	612
	SD (days)	22.36	67.18
	75 percentiles	94	36
	25 percentiles	66	-71

Summary statistics for the length of spring growing season during 1979-2013 at Lay Gaint woreda in the north western Amhara is depicted in (Table 1). As a result, planting earlier than 23 March (DOY 86 i.e. 25 percentiles) is possible once in four years’ time in the study area whereas planting earlier than 11 July (DOY 193 i.e. 75 percentiles) is possible three times in four years’ time in the study area. During the study period, the median of starting date of spring growing season was observed being DOY 137(16 May) in the study area while the mean date of the start of the rains for the study area was DOY 140 (19 May) and the standard deviation was 52 days, i.e. more than7 weeks.The coefficient of variation of the starts of the spring season was found to be high i.e. 37%. Hence, according to Hare (1983) when the coefficient of variation is greater than 30% indicates higher variability. Therefore, it is less dependable to carry out any agricultural activity in the study area. The most common way to assess how climate is changing is by using meteorological observations. For example, in rainfed semiarid agriculture the onset of the rainy season often determines the length of the growing period and thereby suitable combination of crops (Mugalavai et al., 2008). In addition to analyzing the start date of growing season, analyzing the end date of growing season enable plant cultivator to practice their agricultural activity in an organized and planned manner. Therefore, the observed median SprEOS (spring end date of growing season) was seen being at DOY 122 (01-May) in the study area while the mean date of the end of the rains for the study area was day 129 (08 May) and the standard deviation was 29 days, i.e. more than 4 weeks (Figure11). The small rainy season (spring) cessation of earlier than 01 May (DOY 122 i.e. 25 and 75 percentiles) was observed once and three times in four years' time. Medium coefficient of variation (i.e 23%) of the cessation of the small rainfall season result shows medium variation of rainfall to carry out any agricultural activity and it is somewhat detrimental forfarmer to grow crops which require long growing season as well as for land preparation. In general, the variability of crop production in the study could be influenced by late onset of rainfall and early offset of small rainy season. In this study, many years has shown negative growing season. This indicated that it is totaly difficult for farmers to cultivate crops which require adequate mositure during a study perods from 1979 to 2013 (Figure 12). From the data it is clearly indicated that in the study area it is only possible to grow plants which require only 36 days three times in four years periods. During springseason crop growing widely varied from the shortest -91 days to the longest 225 days in the study area during 1979-2013. Hence, the negative growing season indicates the soil is completely dry out and the actual evapotranspiration is greater than potential evapotranspiration. Therefore, soil moisture deficit is occurred. On the other hand, the observed mean lengths of growing of spring season were -11 days and the standered deviation was 67 days. In the present study, the observed CV values also revealed that the spring season length of growing shows extremely variable (i.e 612%). Therefore, the spring season length of growing season is less dependable or reliable to carry out any agricultural activity.

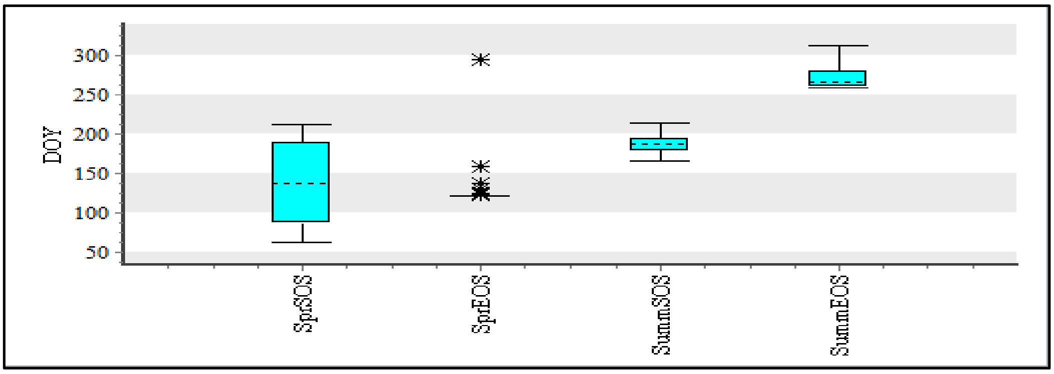

Figure 11. Start and end date of summer and spring season

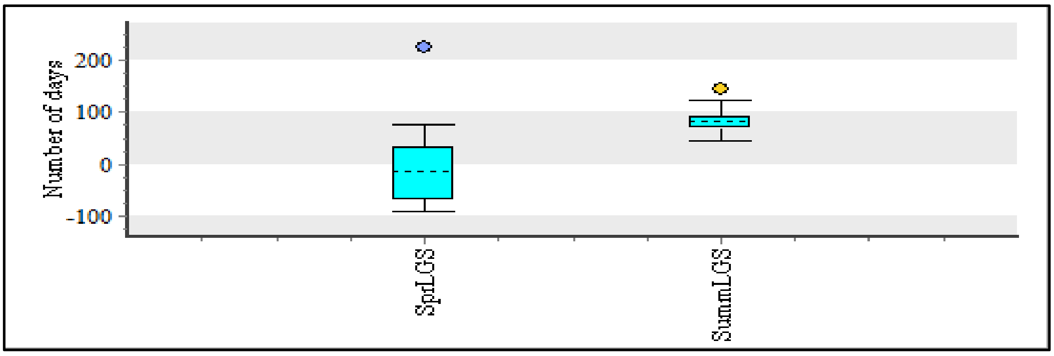

Figure 12. Length of spring and summer growing season

Table 1 indicates the summer season Length of Growing Season/Period i.e. LGS (Figure 12) during 1979-2013 in the study woreda in the North Western Amhara. Therefore, planting earlier than 26 June (DOY 178 i.e 25 percentiles) is possible once in four years' time in Lay Gaint woreda whereas planting earlier than 14 July (DOY 196 i.e. 75 percentiles) is possible three times in four years' time in the study area. During the study period, the median SOS (Start Of Season) of Kiremet growing season was observed being DOY188 (Jul-6) in the study area while the mean date of the start of the rains for the study area was DOY 188 (06 July) and the standard deviation was 13 days, i.e. approximately 2 weeks. In line with this study, Araya and Stroosnijider (2011) and Hadgu et al. (2013) noticed comparable findings of the SOS of Kiremet growing season being between 1st week of July and 3rd week of July in northern Ethiopia. On the other hand, Ayalew et al. (2012) reported June 15 (167 DOY) as a mean date of onset for summer rainfall in the Amhara National Regional State. According to the classification of Hare (1983), the observed variability of Kiremet SOS was lower (CV = 7%) and this shows that the past SOS of Kiremet growing season has been experienced more dependable patterns across the study area. However, these scenarios of rainfall variability has influenced agricultural activities especially tillage, land preparation, sowing and others. In sum, a given meteorological data verified that rainfall shows greater inter-annual variability which it is more unreliable or less predictable to carry out any agricultural activities. Moreover, the observed median end date of summer growing season (EOS) was seen being at DOY 312 (07-Nov) in the study area whereasthe mean date of the end of the rains for the study area was day 272 (28 Sep) and the standard deviation was 14 days, i.e. 2 weeks. The main rain season (summer) cessation earlier than 15 September (DOY 259) was observed once in four years' time while the end of main rainy season earlier than 08 October (DOY 282) is possible three times in four times. Low coefficient of variation (i.e) of the cessation of the main rainfall season result in the time of harvesting of crop was not affected by earlier or later cessation of rainfall and it is more dependable. Based on this data the researcher assured that the variability of agricultural activities mainly crop production in the study relatively influenced by late onset of rainfall but not affected by offset of rainfall. In this study, it is possible to grow crops which require 66 days to mature once in four years' time in the study area while it is also possible to cultivate crops which needs 94 days to mature three times in four years periods in the study woreda. Summer season length of growing periodvaried from the shortest 46 days to the longest 145 days in the study area during 1979-2013. On the other hand, the observed mean lengths of growing season of summer were 83 days and the standared deviation was 22 days. In the present study, the observed coefficient of variation (i.e.27%) also revealed that in the study area, the length of summer growing season is relatively more variable.

Conclusion

The probability of getting rain in the small rainy season in both first and second order markov chain are significantly dependent on whether the earlier dates are dry or wet while the probability of getting rain during the main rainy season is less dependable like that of small rainy season. Hence, the chance of getting rain during spring season substantial increase if it is followed by wet day whereas decrease if it is followed by dry day.Meteorological evidence indicates that the onset of spring and summer rainfall is found to be later than the astronomical first date of spring and summer season in the Northern Hemisphere (NH).On the other hand,meteorological evidence also indicates that the cessation of spring and summer rainfall arrive earlier. This brings an increasing number of dry days, declining monthly total rainfall or premature cessation. The duration of the rainy season or length of growing show greater variation in the study area. Rains in recent years tend to end early; this resulted in reduction of the duration of rainy days in the study area. Onset, cessation and length of growing period of rainfall for the main rainy season shows medium variation compared to the small rainy season.

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